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TITLE ➡ MEASUREMENT OF LATTICE PARAMETER AT THE NANOMII'1'Iii{ SCALE USING CONVERGENT BEAM MICRODIFFRACTION FROM A THERMAL EMISSION SOURCE

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'With the advent of crystal growth techniques which enable device structure control at the atomic level has arrived a need to determine the crystal structure at a commensurate scale. In particular, in epitaxial lattice mismatched multilayers, it is of prime importance to know the lattice parameter, and hence strain, in individual layers in order to explain the novel electronic behavior of such structures. in this work higher order Laue zone (holz) lines in the conver-gent beam microdiffraction patterns from a thermal emission transmission electron microscope (TEM) have been used to measure lattice parameters to an accuracy of a few parts in a thousand from nanometer areas of material.

Although the use of CBM 10 measure strain using a dedicated field emission scanning transmission electron microscope has already been demonstrated[1], the recording of the diffraction pattern at the required resolution involves specialized instrumentation. in this work, a Topcon ()()?13 TEM with a thermal emission source with condenser-objective (CO) electron optics is used. As many TEM manufacturers have adopted the CO mode as standard for high resolution electron microscopy, the technique described here should be practical in dozens of laboratories across the world without the need for additional specialized equipment or a more expensive field emission TEM.

By demagnifying the electron source using the condensor lenses, the beam can be made coherent and a convergent probe down to 0.5nm in diameter can be formed at the sample. Figure 1 shows a density, trace across such a probe. By recording the deficit holz lines in the transmitted beam, the lattice parameter of the material through which the beam has passed can be determined[2]. Al though the electron intensity of such a pattern is much lower than the intensity from a field emission source, the inherently very large signal-to-noise ratio enables real time observation of the pattern via an image intensifier. The exposure time is typically a few seconds, short enough to avoid specimen drift under the probe. An added advantage of the demagnification of the source is the avoidance 01' probe wobble which is observed with field emission due to instabilities in the source.

Figure 2 shows a cross-section of a III-V quantum well (QW), together with (iii'1'raction patterns anti matching holz line simulations with the probe positioned on the GaAs substrate and $In_xGa_{1-x}As$ QW. The substrate pattern is used to determine the accelerating voltage of the microscope (which in general is not known with sufficient accuracy) by using the known lattice parameter of GaAs. This accelerating voltage, with suitable small dynamical corrections to account for the difference in the electron scattering between the two layers[3], is then used in the simulation of the $In_xGa_{1-x}As$ CBM pattern. It is assumed in the simulation that the QW is epitaxial on the substrate (as evidenced by the lack of misfit dislocations at the interface) and that therefore x, the in content, is the only free parameter. A good match is obtained for an in content of 0.26± ().()1, which corresponds to an absolute accuracy in the lattice parameter measurement of 8 parts in 1(),( )()().4

References

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3. Y. P. Lin *et al.*, Ultramicroscopy (1989) 27 233
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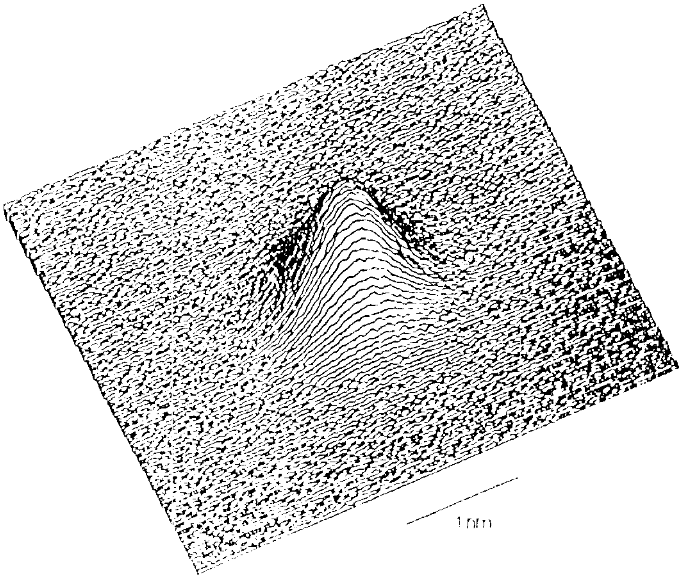

Fig. 1: Intensity profile of probe. Full-width-half-maximum is 0.5nm

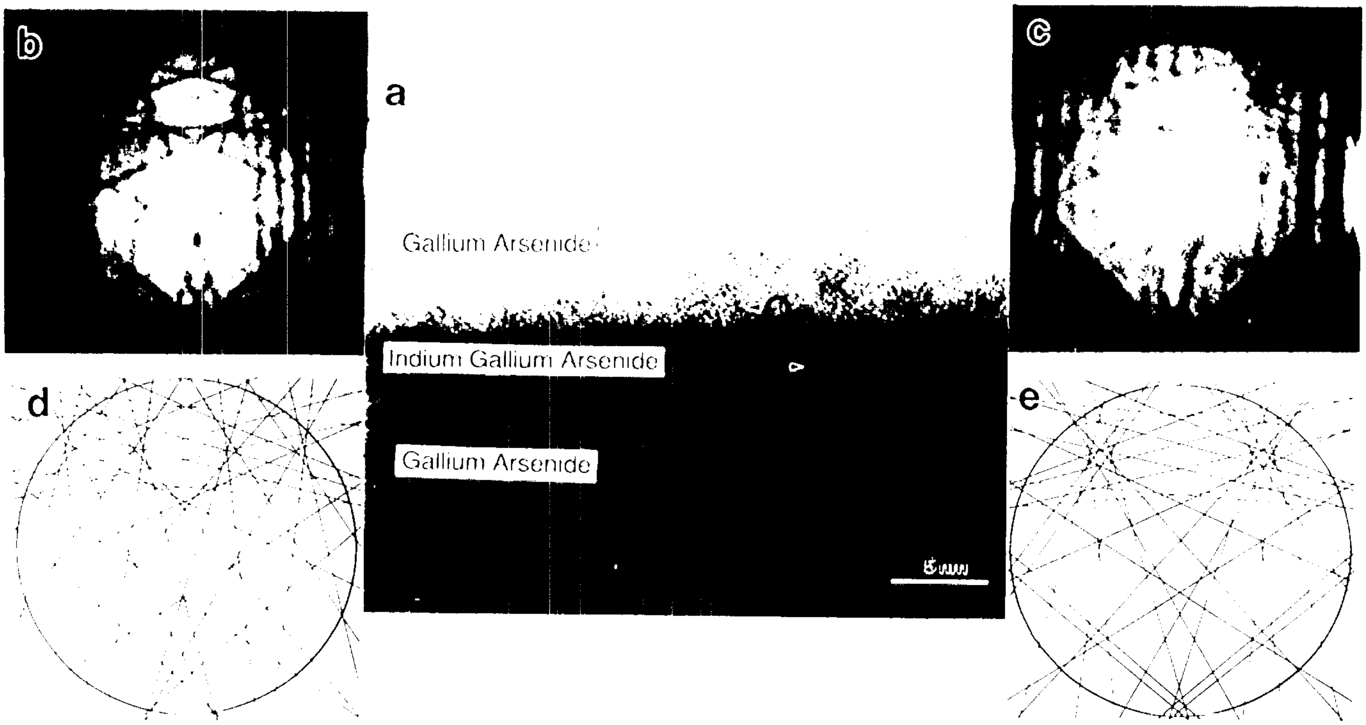

Fig. 2: (a) Cross-section of QW structure showing schematically position of probe for acquiring CBM patterns from (b) GaAs and (c) $In_xGa_{1-x}As$ with dynamically corrected kinematical simulations (d) and (e).